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PROCEDURES FOR TESTING PASTEURIZATION EQUIPMENT

H. E. Eagan

Communicable Disease Center
Atlanta, Georgia

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TRAINING PROGRAM

Procedures for

TESTING PASTEURIZATION EQUIPMENT

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

48

PROCEDURES FOR TESTING PASTEURIZATION EQUIPMENT

H. E. EAGAN
Environmental Health Training Section
Training Branch

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
Communicable Disease Center
Atlanta, Georgia

I

Public Health Service Publication No. 731

II

foreword

The information contained in this bulletin is available in the *Milk Ordinance and Code 1953 Recommendations of the Public Health Service* (P.H.S. Publication No. 229). However, a detailed manual of procedures has been in demand by trainees and public health officials. This manual, a revision of an earlier publication, provides a ready reference for the milk sanitation trainee concerning the methods of conducting the important tests on pasteurization plant equipment.

The highly technical developments on the design of automatic controls of milk pasteurization equipment make it mandatory for health officials to conduct equipment tests to assure the positive pasteurization of milk. Equipment testing used in conjunction with the laboratory tests for phosphatase as well as coliform bacteria in the final product should enable the health official to assure the public of a safe, palatable supply of milk and milk products. This will further the control of communicable diseases and thus increase our Nation's vitality.

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PART I

Equipment Needed to Test Pasteurization Plant Equipment*

EQUIPMENT NECESSARY FOR TESTS ON VAT-TYPE AND HTST PASTEURIZERS

Agitators – Long-handled milk agitator supplied by dairy equipment houses

Alkalinity Test Kit – An A.B.C.B. Alkalinity Test Kit.* Listed by American Bottles of Carbonated Beverages, Washington 25, D. C.

Caustic Test Kit – An A. B. C. B. Caustic Test Kit. Listed by American Bottlers of Carbonated Beverages, Washington 25, D. C.

Chlorine Test Kit – Ortho-Tolidine Colorimetric Comparison Kits and sodium thiosulphate titration kits (more commonly known as starch iodine test kits), may be obtained from detergent manufacturing companies or may be prepared in a laboratory. (See page 188 of Milk Ordinance and Code.)

Containers – The 10-gallon milk cans usually can be borrowed from the milk plant operator to conduct tests.

Phosphatase Kit. The Scharer Rapid Phosphatase Test Kit, for use in the field, may be obtained from Applied Research Institute, 2 E. 23d St., New York, N. Y.

Stopwatch – An accurate stopwatch with sweep second hand.

Thermometer** – Inspector's maximum self-registering. Scale range, 138° F. to 148° F., with the 138° F. point to be not less than

*The use of trade names of materials and equipment, and the names of firms known to supply them, does not constitute endorsement by the Public Health Service. Therefore, no advertising claims can be based on this information.

**The accuracy must be checked at frequent intervals against a thermometer that has been tested for accuracy by the U. S. Bureau of Standards.

three-fourth inch above the bulb contraction. Smallest scale division to represent 0.2° F. Number of degrees per inch of scale not more than 6. Accurate to 0.2° F. plus or minus between 142° F. and 145° F. Pocket metal case provided with suspension ring and clip. Listed by Taylor Instrument Co., Rochester, N. Y., catalog no. 21888.

Inspector's General-Purpose Thermometer

Type – Pocket type; mercury-actuated.
Magnification of Mercury Column – To apparent width of not less than one-sixteenth inch.
Scale Range – 30° to 212° F., with extension either side permitted.
Temperature Represented by Smallest Scale Division – 2° F.
Number of Degrees per Inch of Scale – Not more than 52.
Accuracy – Within 2° F., plus or minus.
Case – Metal provided with suspension ring and fountain-pen clip.
Bulb – Corning normal, or equally suitable thermometric glass.
Listed by Taylor Instrument Co.

EQUIPMENT NECESSARY FOR THE PERFORMANCE OF TESTS ON HTST EQUIPMENT ONLY

Electrical Conductivity Instruments

Two Standard Electrodes – Equipped with adapters which fit all sizes of 3A standard fittings.

Syringe – 50 ml. or 250 ml. veterinarian.

Stopwatch – Standard with one-fifth second intervals.

Salt (sodium chloride) – Available at all grocery stores.

Timers

Wheatstone Bridge – Solu-Bridge Model RD. – 40, manual.
Solu-Bridge Model RT. – 3, automatic.

May be procured from the Industrial Instrument Co., 89 Commerce Road, Cedar Grove, N. J., or the Luminite Electronic Co., 407 So. Dearborn Street, Chicago, Ill.

Meters

Galvanometer – taunt suspension, Model B with proper shunt. Available from Fisher Scientific Co., 711-723 Forbes Street, Pittsburgh, Pa.

Milliameter – D. C. Model AEC 252, Type DO-41-FSIM. Available from Wisner Manufacturing Co., 122 Hudson Street, New York 13, New York, or Sidney P. Foster, 104 Schenck Blvd., Floral Park, N. J.

Gage, Vacuum and Pressure Types – The combined vacuum-pressure gage known as the Vogt Freezer gage is of sanitary construction. It is a 2-inch sanitary pipe size, but with sanitary adapters may be used on all sizes of pipe.

Records – Public Health Service forms PHS-723-2 (San) Rev. 4-53, may be obtained from the Government Printing Office, Washington 25, D. C., at a nominal cost, or may be duplicated locally.

Tachometer – A revolution counter is used for determining the speed of milk pump shafts.

Thermometer – Inspector's scale range 138° F. to 165° F., length 12 inches. Mercury actuated, standardized for 4-inch immersion, contraction chamber immediately above bulb not over 1 inch long. The 138° F. point not to be less than 1 inch above immersion line.

Accuracy within plus or minus 0.2° F. This thermometer must be checked against a thermometer certified by the U. S. Bureau of Standards. Taylor Instrument Co.

Thermometer Holder – I.A.M.D. Fitting No. 55 – A O 1½-inch, 2-inch, 3-inch, and 4-inch sizes. Rubber thermometer gaskets. Taylor Instrument Company.

Note: *Manufacturer listed above are those known to supply the equipment described. It is not implied that this information is complete.*

PART II

Tests of Vat-Type Pasteurization Plant Equipment

The 1953 edition (Third Printing – 1955) of the Public Health Service Milk Ordinance and Code (hereinafter referred to as the Milk Ordinance and Code) sets forth certain tests to be made on pasteurization plant equipment and certain other tests in connection with the processing of fluid milk, initially and at stated intervals.

It is extremely important to keep all pasteurization plant equipment, processes, and operations at the highest level in order to insure the safety of the final product of such plants. The health officer should check the records of each plant at frequent intervals to determine possible variations in equipment or methods of operation. He should see that the tests are made on each piece of equipment at stated time interval shown in the code.

The test number (TEST 1) corresponds to the test number on Form PHS-723-2(San)Rev. 4-53, and the Appendix to the Code, page 199. It is *not* intended that the health officer shall conduct the tests in sequence as outlined, but that each test is to be conducted as an independent test.

● TEST 1. TEMPERATURE ACCURACY OF PASTEURIZATION INDICATING THERMOMETERS (Initially and every six months)

Reason

To assure that all indicating thermometers are in good repair and accurate in response.

Test

Prepare 10 gallons of water in a milk can by raising the temperature of the water to approximately 145° F. using steam, with a range of 142° to 145° F. Keep the water well agitated. (Caution: Do *not* leave steam hose in the water while making the test.) Lower the

indicating and the maximum self-registering thermometers into the water. Using a manual agitator, stir water constantly with vigorous rotary motion. Check temperature of the indicating thermometer against that of the maximum self-registering thermometer. Repeat the test, and take a second reading. Make a record of the thermometer number and the vat number and of the findings. The indicating thermometer and the check thermometer should read within 0.5° F. of each other in the temperature range of 142° and 145° F. If necessary, adjust the scale plates on the indicating thermometer. This is accomplished by removing the face plate and loosening the set screws on the scale plates. By sliding the plates up or down in screw slots, adjust the plates to read accurately at an indicated temperature. When proper adjustment has been made, tighten screws securely and replace the face plate. Due caution should be exercised when the capillary tube has been etched on the glass at a certain temperature. If the mercury column has become split or the capillary tube has been damaged, the indicating thermometer must be returned to the factory for repairs.

An indicating thermometer employing silica gel as a moisture-absorbing agent should have the silica gel thoroughly dried out and replaced each time the protective glass cylinder is removed. Care should be exercised to seat the glass cylinder properly.

● TEST 3. RECORDING THERMOMETER – TIME ACCURACY (Initially and every six months)

Reason

If the recorder chart rotates at too high a speed, the holding time may be too short.

Test

Observe to be sure that the recording thermometers are equipped with ***spring*** operated clocks.

Check the chart rotation against an accurate watch. Observe that the recorded time, as indicated by the recorder chart over a period of ***at least 30 minutes***, does not *exceed* the time of 30 minutes. The elapsed ***time*** must be checked against an accurate watch while the pen* is registering at pasteurization temperature. The elapsed time recorded by the chart and by the watch is recorded ***on the chart***. If necessary, ***have the plant operator*** adjust the clock in your presence.

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* *See that the pen is clean and that the ink flows freely. Line should not be over one-fortieth of an inch thick. Paper must be dry and free from moisture damage.*

After proper adjustment has been made, seal the clock. If the adjustment cannot be made, have the instrument returned to the factory for repair.

● TEST 4. TEMPERATURE CHECK OF RECORDER AGAINST THE INDICATING THERMOMETER
(Daily by the operator and monthly by the health officer)

Reason

A recording thermometer is a delicate instrument and as such it is adjustable. The health officer should take every precaution to see that the written record of pasteurization is an accurate record and that it gives all necessary information.

Test

Check the temperature reading of the recorder with the tested (under test 1) indicating thermometer at pasteurization temperature. If necessary, ***have the plant operator*** adjust the recording pen arm to read no higher than the indicating thermometer.

Indicate on the chart (by pencil mark or by moving the pen) the point at which the check was made.

Record the findings, before and after the adjustment has been made ***on the chart***. Place the date and the signature of the inspector on the chart. Make record of findings on departmental records.

Check all charts for the past 30 days of operation. Note particularly the frequency of adjustments and unusual occurrences. If frequent adjustments are necessary by the operator or the inspector, the temperature accuracy test described under Test 2, should be conducted.

Note: *It is advisable to check charts to see that they meet inspection item requirements of Section 7, Item 16p of the Code at this time.*

TEST 10. SOAKER TYPE WASHERS
(Monthly)

PERCENT CAUSTIC

Reason

Certain dilutions of the caustic bath in the soaker type washers may impair the efficiency of the washing operations.

Test

Use an A.B.C.B. Caustic (not alkalinity) Test Kit, available from

the American Bottlers of Carbonated Beverages, Washington 25, D. C. Follow directions contained in the kit after securing a ***well-mixed*** sample from the washer soaking bath. The percent caustic should not be less than the strengths in percentage of causticity corresponding to the following table for the temperature of the bath and length of soak that is in actual use:

Time of Soak in Minutes	Temperature, °F.						
	170	160	150	140	130	120	110
	Concentration of NaOH, Percent						
3	0.57	0.86	1.28	1.91	2.86	4.27	6.39
5	.43	.64	.96	1.43	2.16	3.22	4.80
7	.36	.53	.80	1.19	1.78	2.66	3.98

Dr. D. H. Jacobson, The Milk Dealer, June 1947.

Check the solutions in the can washer. Record results.

PERCENT ALKALINITY

Reason

Alkali solutions which may have the same "percent total alkalinity" may differ widely in hydroxyl ion concentration and thus possess different bacteria inactivation powers.

Test

Use an A.B.C.B. Alkalinity Test Kit, available from the American Bottlers of Carbonated Beverages, Washington 25, D. C. Follow instructions contained in the kit, securing a well-mixed sample from the soaking bath of the bottle washer or the can washer.

Note: *The usual concentration of sodium hydroxide used varies from 1 to 3 percent, rarely up to 5 percent. The minimum recommendation of 1.6 percent free sodium hydroxide with a minimum total alkalinity of 2.4 percent is a usual procedure on average water. However, temperature of the bath, length of the soak, and hardness of the water must be considered.*

PERCENT ACID

Reason

Inhibited muriatic acid and organic acids are used to clean the

lime deposits from the machine or are used in can washers for the removal of deposits from cans.

Test

A number of detergent manufacturers have *acid* determination kits available in solid reagent form. A kit can be constructed by the sanitarian using one 100-ml. Erlenmeyer flask, one 10-ml. burette graduated to 0.1 ml., and a bottle of phenolphthalein indicator. A solution of tenth normal sodium hydroxide is used to neutralize to a colorless point.

Formula: $\frac{.0036 \times \text{c.c. of N/10 NaOH used}}{\text{c.c. of acidified solution tested}} \times 100 = \%\ \text{acid}$

● TEST 11. BACTERICIDAL TREATMENT OF BOTTLES AND CANS
(Four times each six months)

Reason

Properly cleaned equipment surfaces must be properly treated bactericidally to reduce the likelihood of the pasteurized milk being contaminated by contact with untreated surfaces.

Checks To Be Made

Steam – All equipment must be enclosed in a tight cabinet or suitable containers. Temperature at the coldest point should not be less than 170° F. for at least 15 minutes, or 200° F. for at least 5 minutes, at point of discharge of the steam.

Hot Water – All equipment must be immersed in water in a suitable container, and temperature of the water should be not less than 170° F. for at least 2 minutes.

Chlorine – Chlorine water bath should test quickly to standard orthotolidine chlorine test. Initially, chlorine water bath should test at least 100 p.p.m. available chlorine, and after each run should test at least 50 p.p.m. Check exposure period of 2 minutes when the temperature of the chlorinated water is above 75° F. Observe condition of solution for excessive amounts of milk or other organic material. Record results of the method in use.

Quaternary Ammonium Compounds. As the bactericidal effectiveness of Q.A.C. compounds varies as influenced by the concentration of the active agent, temperature, pH, exposure time and interfering substances in natural water. All test kits must be checked. This is

done by checking the reaction against a standardized quaternary solution in waters sequestered in accordance with the procedures outlined in the Milk Ordinance and Code, Appendix F, page 180(d). The label on each quaternary ammonium compound must state the limiting water hardness established for each specific compound.

The use of test kits for quaternary ammonium compounds and detergent sanitizers should be checked with your State health authority.

● BACTERICIDAL TREATMENT OF ASSEMBLED EQUIPMENT (Four times each six months)

Reason

Properly cleaned equipment surfaces must be properly treated bactericidally to reduce the likelihood of the pasteurized milk being contaminated by contact with untreated surfaces.

Checks To Be Made

Steam – Each group of assembled equipment must be treated separately.

Hold thermometer at outlet farthest from steam's entrance. The temperature should be 200° F. and the period of time during which this temperature is maintained ***at outlet*** must be not less than 5 minutes.

Check to see if covers and other closures and unions are "cracked loose" to insure joints being thoroughly steamed.

Weight cans, storage vats, clarifiers, separators, coolers, pasteurization vats, and bottlers must be treated separately with covers in place.

Coolers are to be drained of refrigerant and the intake valves closed before treatment; the return refrigerant valve should be left open. See that covers are in place and tight fitting.

Hot Water (page 89 of Code) – Assemble all equipment.

Hold thermometer in stream of water at inlet of piping. The reading should be 170° F. or better.

Hold thermometer at outlet. The temperature of the water should be 170° F. or better, which should be maintained for a period of 5 minutes.

Cooler must be drained of refrigerant, the intake valve closed, and the return valve left open. See that all surfaces are exposed to the hot water at 170° F., with covers in place. Check temperature with thermometer.

Such surfaces as cannot be reached by the hot water must be treated separately and assembled before treatment is begun.

Chlorine – Assemble all equipment, determine if joints, covers, and other closures are "cracked loose" to insure penetration of chlorinated water.

By standard test, check strength of available chlorine* before starting to pump the solution over equipment. 100 p.p.m. is recommended under usual conditions.

Determine by a watch the length of time the chlorine solution flows at outlet. This is to be not less than 2 minutes.

Determine strength of available chlorine in chlorine water at outlet. This should be not less than 50 p.p.m. at the end of the run.

All surfaces not reached by flow must be sprayed with suitable strength chlorine water (200 p.p.m. is recommended).

● PHOSPHATASE TEST
(When laboratory phosphatase test positive)

Reason

The results of a positive phosphatase test will show significant deficiencies in pasteurization, e.g., a drop in temperature of 1½° F. below 143° F.; a shortage of 10 minutes or more in the required 30-minute holding time; the presence in the processed milk of as little as one-tenth percent of raw milk.

Test

Health departments that have the use of the State laboratory should submit samples for the phosphatase test each month to the State laboratory.

Health departments that do not submit milk samples regularly to the State laboratory should secure a Scharer Rapid Phosphatase Test Kit.

Follow directions, ***as furnished with the kit***, explicitly.

Avoid the use of plastic stoppers.

Do not permit fingers to come in contact with samples, tubes, or stoppers.

Use distilled water for all reagents. Rinse tubes, stoppers, and droppers with distilled water.

Do not use tobacco while conducting test.

Use clean droppers for each sample.

Avoid the presence of phenol (carbolic acid) at all times.

**If chloramines are used, make a record of the name of the manufacturer and amount of stock used.*

Use "chemically pure" grade of normal butyl alcohol that does not contain phenol.

It is advisable to keep all reagents under refrigeration.

● BACTERIOLOGICAL WATER TEST
(Water supply approved as safe by the State Board of Health; samples of private supplies every six months and after all repairs)

Reason

Water comes in contact with all equipment used in the pasteurizing plant. Its purity is paramount.

Test

Take a sample of water from an outlet, preferably in the pasteurizing room or the supply of water as used. Take all necessary precautions to assure against sample contamination. The State boards of health issue instructions for collecting water samples. Record results as reported by the laboratory.

Note: *Rubber hose should be on protecting racks when not in use; they should not be allowed to lie on the floor. Before taking any samples, inspect the construction of the water supply system for defects. If a cross connection or any unusual conditions exists, report the defect, in detail, to the State Board of Health.*

Short-Time, High-Temperature Operations

Observe the construction and protective covers of all sweet water refrigerating tanks. If fully protected, take sample water for analysis.

● TEST 2. RECORDING THERMOMETER – TEMPERATURE ACCURACY
(Initially and every six months)

Reason

This test should be made if at any time it is found that frequent adjustments of the recorder are necessary.

Recording thermometers should be capable of recording correct temperatures after being subjected to a wide and sudden fluctuation in temperature.

Test

Fill one suitable container with water heated by steam hose to 212° F. with live steam, keeping the steam hose in the can with steam valve just open. Fill another suitable container with melting ice. Place both cans within working distance of the recording thermometer bulb and the vat.

Adjust recorder pen to read correctly between 142° F. and 143° F. against a tested indicating thermometer (Test No. 1).

With the milk at pasteurization temperature and with agitator on, allow a 5-minute stabilization period with the recorder bulb in the milk.

Remove bulb of recorder and immerse in boiling water for 5 minutes.

Remove the recorder bulb from the boiling water and immerse in the melting ice for 5 minutes.

Place bulb of recorder back in pasteurizer with milk 142° F. to 145° F., with agitator on.

Within a reasonable time, the reading of the recording thermometer should be within 1° F. of that of the tested indicating thermometer.

Note: ***Mark each vat with a number, plainly visible. Have each recording thermometer numbered to correspond to the number of the vat in which it is to be used. If the vat and the thermometer have a serial number, these numbers may be used for identification.***

● **AGITATION**
(Initially)

Reason

The difference in temperature of the milk at pasteurization temperature and any milk in the vat should not exceed 1° F.

Test

No acceptable test has been devised for general field use. Therefore, the inspector must make sure that the following conditions of construction and operation will prevail in order that the milk will be uniformly heated throughout the vat:

The agitator should be so constructed that when the milk reaches the lowest tip of the thermometer bulb, the milk will be agitated thoroughly.

The agitator must be working throughout the entire holding period while the milk is at 143° F.

The *outlet* valve seat must be flush with the inner wall of the vat; or, if the valve seat is not flush, the vat outlet must be so con-

structed that the milk will be swept into the outlet by the agitator ***throughout*** the holding period.

Note: *All vats of recent manufacture usually meet all agitation constructure specifications. If you are in doubt, consult the State board of health. In your correspondence, state name of manufacturer, style, serial number, and the capacity of the vat. A record should be made of whether, in the opinion of the health officer, the agitation is adequate or inadequate.*

● TEST 6. FILLING AND EMPTYING TIME
(After any change from initial installation)

Reason

Under certain operating conditions, all the milk in the vat may have not been properly pasteurized even though the chart shows a temperature of 143° F. for 30 minutes. One of these conditions exists when small amounts of milk, such as partial pailfuls at farm plants, are added to the vat after the start of the holding period. Obviously, the added milk will not be held for the full 30-minute period. Another such condition may exist when the milk is heated to the pasteurization temperature before it enters the holder. Since the chart will register the milk temperature as soon as the recording thermometer bulb is submerged, it is obvious that all of the milk in the vat will not be held for the full 30-minute period if the holding time shown by the chart is only 30 minutes.

Similar conditions may arise with respect to cooling. If the milk is entirely cooled outside the holder, the chart will still show the pasteurizing temperature as long as the bulb is submerged, even though the outlet valve is open before the end of the 30-minute holding period. If cooling is started in the holder after the outlet valve is opened, there is no way of determining from the chart whether the holding time was sufficient. To be safe, the milk must be held for 30 minutes, plus the emptying time, to the bottom of the recording thermometer bulb. This penalizes poor operation only. It is better practice to start cooling in the vat before the outlet valve is opened; and, if this is done, the chart record need show a holding time of only 30 minutes (unless the filling time must be added).

Test

Filling Time – Observe the actual conditions under which the pasteurizer is filled.

If the milk is heated to the pasteurizing temperature ***before*** it enters the holder, check the time of filling of each vat from the level

of the bottom of the recording thermometer bulb to a level 1 inch below the bottom of the air space thermometer bulb. Make several readings on separate days, and record the average. Charts must show a holding period of 30 minutes plus this average time. (Also see below for emptying time.)

If the milk is heated to the pasteurization temperature ***after*** it enters the holder, observe whether any milk is added after the start of the holding period as shown on the chart. If so, require that whenever this occurs, the operator shall show a holding time of at least 30 minutes subsequent to that time. If milk is routinely added to the vat during the heating period, it may be recommended that the time of the last addition be noted on every chart. (Also see below for emptying time.)

Emptying Time – Observe the actual conditions under which the pasteurizer or pasteurizers are emptied.

If the milk is entirely cooled outside the pasteurizer, or if cooling in the vat is begun after the outlet valve is opened, check the time of the emptying from a level 1 inch below the bottom of the air space thermometer bulb to the bottom of the recording thermometer bulb. Make several observations on separate days, and record the average. Charts must show a holding time of at least 30 minutes plus this average time. (Also see above for filling time.) The emptying time may vary considerably. This may depend upon several factors including the amount of milk in the vat and the size of bottles being filled. Consequently, the emptying time should be checked with different quantities of milk in the vat, and at different bottling rates, so that charts may be interpreted properly. *The practice of starting to cool in the vat after the outlet valve has been opened should not be accepted, except under controlled conditions.*

If the milk is cooled in the vat, and if cooling is started before the outlet valve is opened, the chart need show a holding time of only 30 minutes, unless the filling time is required to be shown. (See above.)

Note: *Attention is called to the fact that in some cases the charts should show a holding time of 30 minutes plus <u>both</u> the filling time and the emptying time.*

● TEST 7. AIRSPACE THERMOMETER ACCURACY (Initially)

Reason

The airspace indicating thermometer should read 5° F. higher than the temperature of the milk being pasteurized throughout the holding period.

Test

Check thermometer as outlined by test 1 (see p. 4) at 148° F. Record results.

● TEST 8. INLET AND OUTLET VALVES (Initially for plug-type valves and monthly for poppet valves)

Reason

To determine whether inlet or outlet valves actually prevent leakage past the seat in every closed position. If inlet valves leak, raw milk may enter the pasteurizers during the holding period. If outvalves leak, incompletely pasteurized milk may enter and contaminate the outlet piping.

Test

Determine:

That pipe joints, if soldered, are smooth, flush, and tight.

That the mating grooves on all leak protector valves are at least 3/16-inch wide and at least 3/32-inch deep at center of groove throughout their combined length in the "fully closed position." All single leak grooves and all mating grooves, when mated, extend throughout the entire depth of the seat, to prevent air binding.

That grooves are not clogged by dried milk or by washers and similar obstructions.

That all plug-type outlet valves and all new plug-type inlet valves are provided with effective "stops," the stops to assure the operator that the valve is in a fully closed position.

That if the inlet valve is not provided with an air escape, an air hole is provided in the pasteurizer inlet line below the lid of the vat, but above the maximum milk level.

That all valves are free of warping, denting, foreign particles, and improper adjustment.

That there is no leakage at valves. Test each valve in place in the ***fully closed*** position, with milk in contact with the upstream face of of the valve, but with the piping disconnected from the valve outlet so that leakage past the valve seat will be readily visible. Plug-type valves with leak protection grooves should show no leakage past the valve seat.

Test

Check thermometer as outlined by test 1 (see p. 4) at 148° F. Record results.

● TEST 8. INLET AND OUTLET VALVES (Initially for plug-type valves and monthly for poppet valves)

Reason

To determine whether inlet or outlet valves actually prevent leakage past the seat in every closed position. If inlet valves leak, raw milk may enter the pasteurizers during the holding period. If outvalves leak, incompletely pasteurized milk may enter and contaminate the outlet piping.

Test

Determine:

That pipe joints, if soldered, are smooth, flush, and tight.

That the mating grooves on all leak protector valves are at least 3/16-inch wide and at least 3 32-inch deep at center of groove throughout their combined length in the "fully closed position." All single leak grooves and all mating grooves, when mated, extend throughout the entire depth of the seat, to prevent air binding.

That grooves are not clogged by dried milk or by washers and similar obstructions.

That all plug-type outlet valves and all new plug-type inlet valves are provided with effective "stops," the stops to assure the operator that the valve is in a fully closed position.

That if the inlet valve is not provided with an air escape, an air hole is provided in the pasteurizer inlet line below the lid of the vat, but above the maximum milk level.

That all valves are free of warping, denting, foreign particles, and improper adjustment.

That there is no leakage at valves. Test each valve in place in the ***fully closed*** position, with milk in contact with the upstream face of of the valve, but with the piping disconnected from the valve outlet so that leakage past the valve seat will be readily visible. Plug-type valves with leak protection grooves should show no leakage past the valve seat.

● TEST 9. ACCUMULATION OF UNPASTEURIZED MILK IN CHANNEL OF OUTLET VALVES (Initially)

Reason

To assure that no raw or improperly pasteurized milk becomes trapped in the valve channel, when the valve is closed, later to be discharged into the outlet pipe lines, thus contaminating the pasteurized milk.

Test

Each valve shall be tested in place by shutting off the flow of milk (or water in lieu of milk) through the valve, catching the discharge through the leak grooves in any convenient container, and determining its volume. The volume of milk caught should be approximately equal to the capacity of the valve channel (the plug channel in the case of plug-type valves). For plug-type valves, the capacity of the channel can be determined approximately by removing the plug, covering one end of the channel with waterproof material such as cellophane, and filling the channel with water from a measuring cup or a graduated cylinder. For other types of valves, the capacity of valve channel may be determined in a similar manner. Repeat the tests with the valve in several positions, making certain that fully closed and just-closed positions are reached as determined by the stops.

Note: *A poppet valve is any valve that rises perpendicular to or from the valve seat.*

PART III

Tests of Short-Time High-Temperature Pasteurization Plant Equipment

The equipment for pasteurizing milk at relatively high temperatures and short holding periods requires that delicate and accurate determinations be made by the health officer.

This outline develops a logical working sequence of the series of tests. Test numbers referred to in the instructions in this part of the Handbook are the same as those found on PHS Form 723-2 (San) Rev. 4-53, "Pasteurization Plant Equipment Tests Form."

All tests are made on newly installed equipment.

● INDICATING THERMOMETER

Step 1. Temperature Accuracy
(Every six months)

Prior to field determinations, check the inspector's thermometer against a known accurate Bureau of Standards thermometer.

At the plant, heat a can of water to a temperature between 160° F. and 163° F. While water is being agitated vigorously, insert the indicating and inspector's thermometer in the bath. Take two readings of comparison. If necessary, adjust the scale reading to the etching on the capillary of the thermometer. Record the readings as test 1. Remember to dry the cylinder thoroughly before replacing, in order to prevent fogginess.

Step 2. Thermometric Lag
(Every six months)

Adjust a can of water to a temperature of 161° F. Have the inline indicating thermometer adjusted to room temperature and the stopwatch adjusted to zero seconds. While keeping the water bath violently stirred with a milk stirrer, insert the indicating thermometer. Using an accurate stopwatch, observe accurately the time it takes the mercury to rise from 142° F. to 154° F. If this elapsed time exceeds 4 seconds, the thermometer should be replaced. Record as test 13.

● RECORDING THERMOMETERS

Step 1. Temperature Accuracy
(Every six months)

Initially and every six months. While machine is in operation at pasteurization temperature (161° F. plus), check the recorded temperature against the previously tested indicating thermometer. They should read exactly the same, but no higher than indicating thermometer. Record the results as test 2.

Step 2. Deviation of Recorded Reading from Indicating Thermometer
(Daily by plant operator and monthly by inspector)

If necessary, adjust the recorder to read exactly with the tested indicating thermometer between the temperatures of 160° F. and 163° F., after the machine has had a 5-minute stabilization period. Remove the bulb of the recording thermometer, and immerse in boiling water for 5 minutes. Immediately immerse the bulb in melting ice for 5 minutes. Place bulb back in pasteurizer. Check with the indicating thermometer between the temperature of 160° F. and 163° F. The temperature of the recording thermometer should read within 1° F. of that of the tested indicating thermometer. Record as test 2.

Step 3. Time Accuracy
(Initially and monthly thereafter)

Set stopwatch at zero seconds. Move the pen arm slightly at any point while the clock is in rotation. Start the stopwatch at the same instant. Observe for a period of 30 minutes. Move pen arm slightly as you stop the watch. Observe carefully the elapsed time recorded as against that of the stopwatch. Record the results as test 3. (The longer the elapsed time observed, the more minute time deviation that will be noted.)

● MILK FLOW STOP CONTROLLERS
(Monthly)

Milk Flow Stops – Cut-in, Cut-out

(Note: All new milk flow stops on newly installed equipment must be actuated by the same bulb as the recording thermometer.)

When a milk pump stop is used in lieu of a flow diversion valve, it is so designed that the forward flow of the milk cannot start unless the temperature of the milk at the actuating bulb is at or above pasteurization temperature.

While the milk is at or above pasteurization temperature, reduce the milk temperature by the steam temperature controller at a rate of not over 1° F. per each 30 seconds. Check the temperature of the *indicating* thermometer when the milk pump stops. This is the cut-out temperature. Record the results as test 14.

When the machine is at sub-legal temperature, remove the indicating thermometer and controller bulb and immerse the indicating thermometer and the controller-recorder bulb in a bath of water which is below pasteurization temperature. Raise the temperature of the bath slowly, read indicating thermometer at the temperature the milk pump starts. This is the cut-in temperature. If both cut-in and cut-out occur at legal temperatures, seal the actuating setting control box. Record the results as test 14.

● FLOW DIVERSION VALVE CUT-IN, CUT-OUT TEMPERATURES (Monthly)

Step 1. Cut-in Temperature

Heat a 10-gallon can of water to 155° F. Place recorder bulb and the accurate indicating thermometer in the water. (The indicating thermometer is read to determine the exact temperature of the cut-in of the flow diversion valve.) Increase the temperature of the water at a rate not to exceed 1° F. per each 30 seconds until the moment the cut-in mechanism is actuated. If necessary, adjust the cut-in temperature controller to cut-in at a temperature above 161° F. Repeat the test. Record the results as test 14.

Step 2. Cut-out Temperature

After the cut-in temperature has been determined and while the temperature of the water bath is above the cut-in temperature insert the bulbs of the recorder – controller and the indicating thermometer into the water bath. Allow the water to cool slowly while maintaining violent agitation of the water. At the moment the cut-out mechanism in the recorder-controller is activated observe the temperature of the indicating thermometer. Repeat the test. Record the findings as test 14.

● THERMOMETRIC LAG (Every six months)

Allow the recorder-controller bulb to cool to room temperature. In the meantime, heat the can full of water to 7° F. above the cut-in

temperature as determined in test 14. While agitating the water vigorously immerse the bulb. Observe the time it takes for the recorder pen arm to pass the chart reading twelve degrees below the cut-in temperature to the moment the recorder-controller cut-in mechanism is actuated. This is 63% of a 19° F. rise. Record findings as test 16. The time interval should not exceed 5 seconds.

Note: *Rest the can on the hose. It is essential that a constant temperature be maintained. The recorder-controller bulb should be immersed to a depth equal to its normal operating depth. The effect of elevation on the hydrostatic effect within the capillary system and the Bourdon coil depends on the density of the actuating fluid. The actual error is not large. The correction factor that applies to the normal thermometer is 0.0875° F. for each foot of deviation from the normal operating height. This applies to all recorder-controllers using an ether derivative.*

● **MILK FLOW STOPS – RESPONSE TIME**
(Monthly)

Have the recorder-controller bulb above the cut-in temperature. Allow the water bath to cool gradually. At the moment the cut-out mechanism is energized, start the watch; at the moment the flow diversion valve is in fully diverted position, stop the watch. In case of a milk pump stop system, observe the interval of time between the energizing of the cutout mechanism and the complete stopping of the pump's forward motion. The time lapse should not exceed one second. Record result as test 17. (This is usually recorded as "less than one second.")

● **PUMP AND HOLDING TUBE**
(Every six months or changes in the system)

Step 1. The Holding Tube

Observe that the holding tube meets the following conditions: (1) The standard is permanently placed; (2) the rests are permanently aligned; (3) the holding tube slopes upward downstream; (4) if multiple turns are utilized in the piping, short pieces of tubing at opposite ends are of unequal length.

Step 2. Simultaneous Temperature Difference (Initially)

Observe that holding tubes under 7 inches in diameter are con-

structed free of any fittings through which the milk may not be thoroughly swept.

Observe that the holding tube cannot be heated (conventional design).

Determine the temperature of the cross section of flow by the use of thermocouples. The difference between the coldest and hottest flow should not exceed 1° F. This will depend on the size of tube and the velocity of flow.

Note: Reynolds number of 3,000 or over will provide turbulence to the milk. Reynolds number is determined by:

$$\frac{D \times F}{KV} = \text{Reynold's Number}$$

D = inside diameter of the tube

F = flow-in feet per second

KV = kinematic viscosity of the liquid

Water at 60° F. = kinematic viscosity of 0.00001217

Water at 160° F. = kinematic viscosity of 0.000442

● HOLDING TIME

Step 1. Preliminary Equipment Arrangement

Adjust all valves or other flow-impeding devices to the wide-open position.

All holding-time determinations are repeated six times. The average of the six fastest trials is recorded as the holding time for the water in the forward flow or the diverted flow. Clarifiers and separators should not be operating. Homogenizers should be operating without pressure on the valves. In-line filters must be removed. Vacuum systems in lines must be at maximum vacuum.

Step 2. Apparatus and Materials

Electrical conductivity instrument

Two standard electrodes — one with syringe connection

Adapter to fit all sizes of 3A fittings

Syringe — to fit syringe connection on the electrode

Salt (concentrated solution)

Stopwatch

Step 3. Conducting the Test

Insert the No. 1 electrode at upstream end of holding tube. Adapters and fittings may be obtained from instrument manufacturer or from dairy supply houses.

Insert the No. 2 electrode in the sanitary fitting at the downstream end of the holding tube, or it may be inserted in the indicating thermometer fitting.

Connect electrodes of the conductivity instrument to the source of electricity; close the circuit to the No. 1 electrode.

Using water instead of milk, operate the pasteurizer in exactly the same way that it is operated in the pasteurizing process.

Prepare a saturated solution of salt. Usually, a quart or more should be prepared.

Fill a syringe with 50 ml. of the saturated salt solution.

Insert the tip of the syringe into the groove or fitting at the upstream end of the holding tube.

Inject the salt solution, watching the conductivity instrument closely.

Start the stopwatch the instant the instrument registers the first change in conductivity.

Open the circuit of the No. 1 electrode, and close the circuit of the No. 2 electrode.

Stop the watch the instant the instrument registers the second chance in conductivity. The stopwatch reading is the holding time.

Repeat the test six times. The variation between the minimum and the maximum reading should not be over 0.5 seconds. If the variation between the readings is greater than 0.5 seconds, the test shall be repeated until the variation of six successive readings is not greater than 0.5 seconds.

The holding time in the forward flow shall be considered the average of six successive readings, which are within 0.5 second of each other. Similarly, the time in diverted flow shall be the average of six successive readings.

If either average holding time is found to be less than the legal holding time, the capacity of the timing pump may be reduced, the holder may be altered, or other adjustments may be made. Then the timing may be repeated until a satisfactory legal holding time is obtained.

Repeat test with the flow diversion valve in diverted flow.

Step 4. Adjusting the Findings

Since the flow characteristics of water and milk differ, the holding time determined by use of water must be transposed into the holding time for milk. This may be done by either of the methods given below.

Equal Volumes Method: The ratio between the water and milk capacities of the holding tube is found by determining the equivalent time required to deliver equal volumes of water and milk. The sanitarian may use a 40-quart can for this determination. The time values thus found may be inserted into the following formula to obtain the holding time for milk.

$$\text{Holding time for milk} = \frac{T \times Mv}{Wv}$$

Where T = Holding time with water

Mv = Time required to deliver a measured volume of milk

Wv = Time required to deliver an equal volume of water

Equal Weights Method: The holding time for milk may also be calculated by determining the times required to deliver equal weights of milk and water. Milk is heavier than water; therefore, a given weight of milk will occupy less volume than the same weight of water. As a result, the specific gravity of milk is to be taken into consideration when determining the holding time for milk by the equal weights method. For all practical purposes, a value of 1.032 may be used as the specific gravity. It is realized that the specific gravity of milk varies, but a reasonably accurate determination can be made using 1.032. The formula for determining the holding time for milk by the equal weights method is as follows:

$$\text{Holding time for milk} = \frac{T \times Mw \times 1.032}{Ww}$$

Where T = Holding time with water

Mw = Time required to deliver a weighed quantity of milk

Ww = Time required to deliver an equal weight of water

1.032 = Specific gravity of milk

Reference: Public Health Bulletin No. 220 (1953). Journal of Milk & Food Technology, Vol. 13, No. 5, Sept.-Oct. 1950. (3A-Standards.)

Step 5. Sealing the Pumps

When the drive pulley on the positive displacement metering pump has been adjusted to permit the maximum flow of milk that meets the legal standard, the pump pulley is locked. Seal the pulley at this point on the inside. Do not seal the outside of the pump as this will prevent maintenance.

When homogenizers are used as a metering pump, determine the inside diameter of the holding tube, and the length and the pitch of the tube. Record the r.p.m. rating of the motor. Seal the drive shaft casing through the bolts provided; or stamp identification marks across the shaft and gear, or shaft and pulley, of both the drive and driven gears or pulleys.

Two speed homogenizers must be checked for time at both speeds of forward and diverted flows. The interlocking controls must be inspected and tested for the automatic features.

PART IV

Inspectional Aspects Relative to Short-Time High-Temperature Pasteurization

The inspection of short-time, high-temperature equipment includes the engineering design of the initial installation, the detection of any alteration to the design after the initial installation, and the daily operation and maintenance of the equipment. Inspection for cleanliness and bactericidal treatment is of utmost importance, but is not included in this outline.

● CONSTRUCTION AND REPAIR OF EQUIPMENT

Step 1

The Milk Ordinance and Code, Section 7, Item 9p, "Sanitary Piping," is applicable, and items mentioned should receive detailed inspection by the health officer. Section 7, Item 10p, "Construction and Repair of Containers and Equipment" is also applicable in each detail.

Step 2

Thermometers: Check all thermometers, indicating and recording, against specifications in the Code. Identify all thermometers by recording the number of the thermometer or by numbering the thermometer by using a metal tab or proper paint. Record the number and location for positive future identification. Observe that frequency pen and recorder pen are in the same reference arc.

Step 3

Check all thermometers for compliance with specifications.

Step 4

Check the thermometric system for dependable thermostatic controls. To do this, there is a series of steps to be followed. The inspector must first determine if the forward flow of the milk is controlled by the starting and stopping of the milk pump or by a flow-diversion valve.

Step 5

Make sure that the milk line from the diversion side of the valve returns the underpasteurized milk to the surge tank or to the raw-milk pipe line.

Step 6

Be sure that a sanitary orifice is installed in the diverted milk line to assure the same holding time in the diverted flow as in the forward flow of milk, or, that the timing of the pump is so adjusted as to assure that the diverted flow of milk is no faster than the fastest time of the forward flow of milk.

Step 7

Check the assembly of the tee or cross through which the in-line indicating thermometer bulb and the recording-controller actuating bulb are inserted into the milk. These bulbs must be continuously covered by the milk and adjusted in the line so that they are not affected by hot or cold air drafts.

Step 8

Check the diaphragm on the flow-diversion valve for leaks and for proper working condition. Check the air line connections for the accelerated heating connections. This copper ¼" O.D. tube should lead only to the top of the air-operated diaphragm motor on the steam regulator valve.

Step 9

Check rubber disk rings on the flow-diversion valve for position and leakage past the seat. Place the flow-diversion valve in the diverted flow position, uncover the forward flow port, and observe for leakage past the valve seat. (Test with water only.)

Step 10

Clarifiers: Whenever the clarifier is located in the pipe line leading from the regenerator, the metering pump should be timed with the clarifier ***not*** operating. A clarifier operating at 12,000 r.p.m. will set up a back pressure of approximating 50 p.s.i.

Homogenizers: The homogenizer is a positive displacement pump. It may be used as a timing pump or in conjunction with a metering pump. In the latter case, one of three possible conditions may exist: (1) the homogenizer may be slower than the metering pump; (2) the homogenizer may be equal to the capacity of the metering pump; or, (3) the homogenizer may be of greater capacity than the metering pump.

In no case should the homogenizer be capable of creating a forward flow of milk when the metering pump is not running. In case #1 above, a milk line is installed leading to the raw-milk-supply float tank rising in a vertical position from the milk line supplying the homogenizer. (A 60-R pressure relief valve may be installed in this line in place of the vertical pipe.) In cases 2 and 3 above, a by-pass milk line is installed between the unhomogenized-milk line and the homogenized-milk line. The pipe must be of equal size to the unhomogenized-milk line and be unobstructed.

In case neither of these remedial measures is effective, an electrical inter-lock must be installed between the metering pump starter and the homogenizer starter. A four-second delay switch is permissible.

Vacuum Flavor Controls: Whenever a vacuum chamber is installed downstream from the flow diversion valve, it acts as a pump. (Milk Ordinance and Code, 1953 Recommendations of the Public Health Service – 3rd Printing – Section 7, Item 16p(d)(2)(b), p. 119.) An air-relief valve must be installed in the pasteurized-milk line leading from the flow-diversion valve to the vacuum chamber.

A vacuum chamber located upstream from the pasteurized milk side of the regenerator may draw the pressure from the pasteurized milk in the regenerator in case of a shutdown. A check valve or other means must be provided to prevent the back flow of the pasteurized milk.

● DESIGN OF EQUIPMENT

Controls Automatically Stop and Start the Milk Pump Without a Flow-Diversion Valve in the Line

Step 1

Check the wiring from the milk pump to the relay in the "controller-recorder." The wires should lead only to the opposite point contacts on the contactor box through the micro-switch. The cold sterilization micro-switch located in the "indicating temperature controller" box should not be connected into the system.

Step 2

See that all the milk pumps in the system, including the homogenizer (viscolizer), are wired so that all pumps in the system stop simultaneously.

Step 3

Adjust the cut-out temperature at the contactor box at 161° F. or above. Raise the temperature of the milk to several degrees above that set by the contactor; then, by adjusting the water-indicating temperature controller, slowly lower the temperature of the milk. Determine the exact temperature at which the milk pump stops. Make any adjustments necessary on the contactor box. Record the final temperature of cut-out of the pump. Note any slippage of the pump.

Step 4

Attempt to start the pump by slowly adjusting the water-indicating temperature controller to raise the temperature above 161° F. Under **no** condition should the pump start at a temperature below 161° F.

Note: *It should be necessary to remove the bulb of the recorder-controller and place in water of 161° F. or above to start the pump. Record the cut-in temperature, and seal the adjustment screw on the controller box and the cover plate.*

Step 5

Manual switches for starting the milk pump ***are not*** permitted on this type of installation.

Step 6

Note any milk bypass around the bulb of the controller. This bulb ***must*** be in position and ***must not*** be removed during the pasteurization process.

Note: *It may be heated by steam while in place in the line on the initial temperature buildup of the milk.*

Controls Automatically Divert the Flow of the Milk With the Pump in Operation. Holder Not Heated

Step 1

The flow-diversion valve is located downstream from the holder tube in such a position that the actuating bulb of the recorder-controller located in the milk line is ***not*** over 18 inches from the flow-diversion valve. The flow-diversion valve must be mounted in a rigid position, relatively free from vibrations.

Step 2

The Bourdon coil actuating the pen arm of the recorder-controller and the Bourdon coil actuating the contact arm must be operated by the same capillary pressure, i.e., a divided capillary.

Step 3

The controller response acts independently of the recorder arm.

Step 4

Check the micro-switch on the flow-diversion valve for the following wiring: The stem locking key while in place permits the operation of the milk pump starter. In the diverted position, when the key is out of place, the milk pump starter is de-energized; and the pump cannot be started. Improper assembly of valve will also de-energize the pump starter and the pump will not start. With one gasket in place, a one-quarter turn of the 13 H nut must also stop the pump. This applies only to flow diversion valves numbered 39VJ.

Step 5

Tighten the stem packing nut on the flow-diversion valve as tightly as is physically possible. Operate the flow-diversion valve. The stem must act freely in all positions.

Step 6

Check the following actions on the recorder-controller while the flow-diversion valve is in the diverting position with the stem locking key in place:

The milk pump is running.

The red signal light is on.

The frequency pen arm denoting the diversion action is in proper position.

No air is flowing to the top of the diaphragm of the flow-diversion valve.

There is no current running through the top relay in the recorder-controller box.

Step 7

Check the following action on the recorder-controller while the flow-diversion valve is in the forward-flow position:

The milk pump is running.

The green signal light is on.

The air is flowing to the diaphragm on the flow-diversion valve without leaks. Air pressure is at a minimum of 20 pounds per square inch.

Note that all the action is recorded by the two pen arms on the recorder-controller. Cut off the primary power to the machine. This

should automatically stop the pump in the case of a milk-pump stop installation, or should activate the flow-diversion valve in the milk-flow stop system.

Step 8

Check the flow-diversion valve fo a leak escape and note the following:

All the leakage drains to the outside of the valve.

The leak escape lies between the two valve seats or between the two portions of the same seat.

The length of the connecting rod of the valve must be non-adjustable.

The valve seat must depress valve at least 1/16 inch.

Remove the pipe from the outlet of the forward-flow on the diversion valve. Place the valve in a diverting position. Remove all traces of milk in the pipe by use of a clean lactericidally-treated cloth. Operate the machine. There should be no trace of milk past the seat of the valve in this position.

● THE HOLDING TUBE AND PUMP

Step 1

Check the slope of the holding tube with a level. It should slope upward toward the flow-diversion valve. The slope should be no less than one-fourth inch per foot. One-half inch per foot is recommended on tubes of 4 inches in diameter or larger.

Step 2

Check the standards that support the tube. They must be constructed in a permanent position to maintain proper uniform slope.

Step 3

No part of the holder between the inlet and the recorder-controller thermometer bulb shall be heated unless there is *also an upstream* flow-diversion valve or milk-pump stop.

Step 4

Check the type of motor on the constant flow pump. This must be a constant speed induction-type motor; or, if another type of motor is used, a governor must be installed. In case a governor is used, it must be sealed at the maximum speed to assure that the holding time is not less than the legal limit.

Step 5

If the holding tube does not slope continuously upward toward the flow-diversion valve, an automatic vent pipe, open to the atmosphere, must be installed at the highest point nearest the milk-flow stop. The opening must be protected by a hood.

Step 6

Pressure of the milk in the holding tube must be greater than that of the raw milk on the raw-milk side of the pump. *Should a centrifugal pump be installed between the raw-milk surge tank and the positive pump, acting as a booster pump,* this installation must be so wired that the centrifugal pump will not operate unless the following conditions are present:

The metering pump is operating.

The flow-diversion valve is in the forward flow position.

A sanitary pressure switch* located in the pasteurized-milk line downstream from the regenerator section has been closed by the pressure of the pasteurized milk.

A vertical standpipe may be installed, which is open to the atmosphere, on the pasteurized-milk line at a sufficient height to insure a static head pressure of one pound over and above the maximum pressure development by the booster pump. A time-delay switch assures that the proper height of the milk is reached before the booster pump will operate.

**The pressure switch should be set at a mimimum pressure of 2 pounds greater than the maximum pressure that may be developed on the raw milk by the centrifuged booster pump. The same size impeller should be used in the centrifugal pump at all times. The pressure switch must be completely waterproof and capable of being sealed by the health officer. The centrifugal pump and motor must be bolted to the floor and the serial number recorded by the health officer. The diameter of the impeller and the maximum pressure developed by the pump should be stamped on the pump or on the plate attached thereto.*

Taylor pressure switch 745174, having contacts normally open but closing with rising pressure, is usually installed. They are set at the factory to cut out at 5 p.s.i.g. The switch may be adjusted on the job by taking out the two set screws and removing the stainless steel cap. A lock screw moves a dial and can be adjusted to meet the pressure demands of the health officer. Note that it is not necessary to remove the nut holding the wire. Sealing is accomplished by threading a lead wire seal through the holes in the setscrew after it is firmly tightened.

Items required in addition to the above will include an automatic starter switch for the booster pump, a pilot light, armored wiring, and in some installations, an orifice fitting of stainless steel.

The pressure switch is installed by inserting a sanitary tee in the pasteurized-milk line immediately after the milk leaves the regenerator and before it enters the cooling section.

● THE PLATE SYSTEM – POINTS OF INSPECTION

Step 1

All plates should be numbered and stamped. Record the numbers and the sequence of the plates in the heater, regenerator, and cooling sections. Any change in the sequence or number of plates will indicate a change in the holding time and the capacity of the machine.

Step 2

Check all the gaskets for possible leaks.

Step 3

Check the hot-water surge tank. It must be clean and covered. The recirculated water must be free from raw-milk contamination. It is advisable to check this water at intervals for a high thermophilic organism count.

Step 4

The pipes dropping from the final outlet of the heating section to the holding tube should be permanently and clearly identified.

Step 5

The pasteurized milk in the milk-to-milk regenerator section must, under all conditions, be under greater pressure than the raw milk. The pasteurized-milk line leading downstream from the pasteurized-milk side of the regenerator must rise to a height of 6% of the height of the milk in the plates of the regenerator section. The line must be open to the atmosphere at a point above any pasteurized milk in the plate system. The following will assure that this requirement will be met:

Milk level elevations:

The overflow point of the raw-milk supply tank must be below the level of any raw milk in the regenerator.

Accurately observe the level of the milk in the raw-milk supply tank. Disconnect the raw-milk outlet from the regenerator section. Observe that the milk flows back to the raw-milk supply tank when the equipment is shut down. Note: This will require that a 1/16 inch hole be drilled in the flow-diverting plates at the lowest point. The mode of inspection for determining compliance with this standard is to disconnect the raw-milk inlet pipe to the regenerator section, and pass a small-diameter, blunt instrument to the first obstructing plate.

Repeat this process after displacement of the first plate. Each plate that obstructs the passage of the instrument will be required to be drilled.

To assure pressure on the pasteurized-milk side of the regenerator at "Start up," one of the following conditions must exist at the beginning of the run: (1) a pressure switch is installed on the pasteurized-milk line so the metering pump will not operate unless the milk has obtained the proper pressure, or (2) the raw milk is by-passed around the raw-milk sections of the regenerator by automatically operated valves until the proper milk pressure has been reached, or, (3) water, or chemical bactericidal solution, at 170° F. is run ahead of the milk at the startup and is followed immediately with milk without interruption of the flow.

Check all "can off" lines, lines to fillers, etc., to see that no siphonage condition exists, i.e. – line may be open downstream from "can off" line which may break the siphonage effect.

Observe all lines that might connect pasteurized milk with raw-milk pipe lines.

Step 6

There are other potential construction designs of regenerator sections, such as:

Milk-to-milk regenerators with the raw milk open to the atmosphere.

Milk-to-milk regenerators with the pasteurized milk open to the atmosphere.

Milk-to-water-to-milk regenerator sections.

In all the above conditions the specifications are designed to maintain a greater pressure on the pasteurized milk than that existing on the raw milk under all conditions.

Step 7

As the sweet water (hot or refrigerated) in the heating or cooling section of the water-to-milk regenerators with both sides closed to the atmosphere is often under greater pressure than the milk, the following conditions must exist:

The tank or storage must be clean.

The tank must be protected with a tight cover with overlapping edges. All ports are watertight.

The protected recirculated water must be treated with chlorine if necessary. See State Standards.

● INSPECTIONAL FEATURES OF SHORT-TIME HIGH-TEMPERATURE CHARTS

All HTST recording thermometer charts *shall* be preserved for a period of 3 months for the information of the health officer. No chart can be used more than 1 day, except by permission of the health officer. The chart is perforated by the pins on the clock hub, and the holes must not be expanded. All HTST charts shall have recorded on them the following:

1. Date of operation.
2. If more than one HTST unit is operating, number and location of the unit on its respective chart.
3. The indicating thermometer should be read some time during the operating period; a recording of this temperature should be made on the chart immediately.
4. Monthly, the time accuracy of the recorder, as found by official test.
5. Amount and grade of pasteurized milk or milk products represented by charts.
6. Record all unusual occurrences.
7. Signature or initials of operator.
8. A record of the time during which milk-flow stop is in the forward flow position. This may be determined by noting the action of the frequency pen arm. The time during which milk is below sub-legal temperature should correspond to the time the valve is in the diverting position, as shown by the frequency pen arm.
9. The milk temperatures, determined daily, at which the cut-in and cut-out function, and monthly the initials of the health officer, written opposite the readings.
10. Applies to holder heaters: Monthly, the health officer's initials opposite the holder-heating medium temperatures at which the controller of the automatically controlled holder heater, if any cut-out or cut-in has been made in the milk flow.
11. Semi-annually the thermometric lag of the recorder-controller, as found by official test.

● INSPECTIONAL ASPECTS RELATIVE TO VACUUM FLAVOR EQUIPMENT LOCATED ON THE PASTEURIZED-MILK SIDE OF HTST PASTEURIZERS

The inspection of flavor-control equipment includes the engineering design, detection of any alterations in design, daily operation, and

maintenance of the equipment. When steam is in direct contact with the milk, special attention must be given to the steam supply to negate the possibility of product contamination.

Design and Construction of Equipment

The equipment should receive detailed inspection recommended by the Public Health Service for compliance with the Milk Ordinance and Code as set forth in Section 7, Item 9p – "Sanitary Piping" and Section 7 – Item 10½, "Construction and Repair of Containers and Equipment."

Protective Devices to Insure Proper Operation of HTST Pasteurizer

All vacuum chambers located between the flow-diversion valve and the pasteurized-milk side of the milk-to-milk regenerator section must be equipped as follows:

1. An automatic vacuum relief valve must be installed in the line between the flow-diversion valve and the first vacuum chamber. (Taylor Instrument Co; Creamery Package Co.)
2. A positive-action check valve must be located on the discharge milk line from the vacuum chamber to the pasteurized-milk side of the milk-to-milk regenerator. The check valve must prevent the back flow of pasteurized milk to the vacuum chamber in case of a shut-down.
3. A vacuum breaker must be installed in the milk line between the vacuum chamber discharge pump and the milk-to-milk regenerator section at a level above the height of the milk in the milk-to-milk regenerator.

Steam Supply

The following checks are made:

1. All additives to boiler waters are checked for volative and toxic compounds.
2. Check traps and blow downs on steam line for proper operation.
3. Check carbon or ceramic steam filter for proper installation and operation.
4. Check for 1" slope in 20 feet on steam radiation pipe.
5. Check the auxiliary steam filter for installation and operation. Filter must be installed vertically to flow of steam.
6. Check steam injection nozzle for state of repair. In case of a steam infuser, check for potential atmospheric contamination.
7. Check for steam condensate sampling connection.

Ratio Controller (optional)

Automatic control of the composition of milk is desirable. The ratio controller may accomplish this when steam comes in direct contact with the milk or milk product. The controller has two actuating elements. The adjusting unit (blue pen) records the temperature of the product as it leaves the flow-diversion valve. The controlling unit (red pen) senses and adjusts the temperature of the product as discharged from the vacuum chamber by means of an air-actuated vacuum regulator. These pens record the temperatures which indicate the preset ratio between inlet and outlet temperatures. Check the following:

1. Check the ratio-set-point to see that it is set on "direct ratio."
2. Check the chart to determine accuracy of ratio. Rate of temperature losses due to radiation and free convection may be secured from charts furnished by the manufacturer of the installation. The differential to the temperature of the incoming milk and the discharged milk is usually not over 10° F.

Sampling

Samples for checking the efficiency of the system should be taken on the incoming milk and the final product. Samples should represent the same milk and be aliquot.

Laboratory tests must be made by the evaporation-to-a-constant-weight method. Freezing point determinations for added water are not accurate enough for comparisons.

Where automatic controls are not installed on equipment using steam in direct contact with milk, frequent examination of samples should be made to determine whether unadulterated products are being processed.

Installation of Vacuum and Condensant Discharge

This installation should be to the outside atmosphere and installed to eliminate any possibility of back draw of contaminants into milk contact surfaces.

PART V

Tests of Pasteurization Plant Equipment - Vacuum Pasteurizer (Vacreator)

Step 1. Inspection Aspects of the Vacreator

Steam Supply: No volatile or toxic compounds are used to treat the boiler water. The steam is brought from the boiler to the Vacreator passing through a steam collector, steam filter, and steam purifier. The steam line is provided with a steam regulator (to control boiler pressure variations), a steam valve and a minimum-pressure switch.

Product Flow Stop: Note that the positive infeed pump is equipped with a reversible magnetic field on the motor. A change of current will instantaneously reverse the direction of rotation and maintain the reverse rotation for at least two seconds.

The product flow-stop valve is mounted at the Vacreator milk inlet in a vertical position to the milk line. The interval of time from the moment of power cut-out until the valve closes must not exceed one second.

The cross-over pipe from the pasteurizing chamber to the intermediate must be equipped with an indicating thermometer and the bulb of the recorder controller.

The recorder chart should have the smallest scale division of 1° F. between 180° F. and 210° F. The scale division should not be less than one-sixteenth of an inch between 180° F. and 210° F. The smallest time scale division must not be more than ten minutes. The straight line 10-minute scale division must not be less than one-fourth inch between 190° F. and 195° F.

Step 2. Tests for Control System of Pasteurization on Vacreator

The Metering Pump (Initially and every six months): The in-feed metering pump is set and sealed at the maximum capacity that can be maintained at a minimum temperature of 194° F.

The pump capacity is checked by timing the milk flow required to fill a 10-gallon can of milk. (See table, p. 38.)

CONVERSION TABLE FOR PUMP CAPACITY RATINGS AT 40° F.

Rating of Pump in lbs./hr.	Rating in Gals./hr. of 40° Milk	Seconds to Fill a 10 Gal. Can With 40° Milk	Seconds to Fill a 10 Gal Can With 40° Water	Rating of Pump in lbs./hr.	Rating in Gals./hr. of 40° Milk	Seconds to Fill a 10 Gal. Can With 40° Milk	Seconds to Fill a 10 Gal. Can With 40° Water
2500	290.5	124.	120.1	16500	1920.0	18.8	18.20
3000	348.5	103.3	100.	17000	1977.0	18.21	17.69
3500	407.0	88.6	85.8	17500	2035.0	17.7	17.15
4000	465.0	77.5	75.1	18000	2092.0	17.2	16.68
4500	523.0	68.8	66.8	18500	2150.0	16.77	16.21
5000	581.0	62.0	60.1	19000	2210.0	16.3	15.8
5500	639.0	56.3	54.6	19500	2264.0	15.9	15.4
6000	697.5	51.7	50.0	20000	2324.0	15.5	15.0
6500	756.0	47.7	46.25	20500	2385.0	15.1	14.61
7000	814.0	44.25	42.9	21000	2440.0	14.75	14.3
7500	872.0	41.4	40.1	21500	2500.0	14.41	13.96
8000	930.0	38.75	37.6	22000	2560.0	14.1	13.65
8500	987.5	36.5	35.35	22500	2619.0	13.79	13.33
9000	1045.0	34.42	33.40	23000	2679.0	13.49	13.05
9500	1120.0	32.62	31.60	23500	2735.0	13.2	12.79
10000	1161.0	31.0	30.0	24000	2790.0	12.9	12.50
10500	1221.0	29.5	28.6	24500	2850.0	12.65	12.25
11000	1280.0	28.2	27.3	25000	2905.0	12.4	12.0
11500	1338.0	26.95	26.1	25500	2965.0	12.16	11.78
12000	1395.0	25.85	25.0	26000	3020.0	11.91	11.55
12500	1452.0	24.80	24.0	26500	3080.0	11.7	11.31
13000	1511.0	23.85	23.1	27000	3140.0	11.49	11.1
13500	1570.0	22.95	22.25	27500	3200.0	11.28	10.9
14000	1629.0	22.15	21.45	28000	3258.0	11.08	10.7
14500	1685.0	21.40	20.7	28500	3320.0	10.9	10.54
15000	1744.0	20.7	20.	29000	3370.0	10.7	10.35
15500	1801.0	20.0	19.37	29500	3420.0	10.5	10.19
16000	1860.0	19.38	18.78	30000	3490.0	10.32	10.0

Vacuum Switch (Initially, and when seal broken): The vacuum switch is found by taking the cover from the control panel. Remove the head from the in-feed pump in order to observe the shaft rotation. Have the Vacreator operating with normal vacuum. Have the snifter valve to lower the vacuum in the intermediate chamber to 8 inches. Observe that the pump immediately stops at 8 inches of vacuum. Adjust setting if necessary. Seal cover at the two points provided.

Minimum Steam Pressure Switch (Initially, and when seal broken): The steam pressure switch is located on the steam pipe line downstream from the main valve. Have the Vacreator operating. Have the milk flow stop valve in place. Slowly reduce the steam pressure by the valve until 35 p.s.i. pressure is reached. The pump must stop at this pressure and remain stopped at 35 p.s.i. or less. Adjust the regulator on the switch, if necessary. Seal cover of switch box at the two points provided.

Steam Orifice Plate (Initially, and when seal broken): Located in the pipe union just before the steam line enters the Vacreator.

Assemble the in-feed pump and connect the raw product pipe lines.

Adjust the cut-in and cut-out temperature of the recorder controller to actuate at 15° or 20° F. below pasteurization temperature.

Use the plate with the smallest orifice by placing it in position in the union. Tighten the bolts. Place the Vacreator in normal operation. Turn steam valve to fully open. Close the steam bypass valve. Adjust the equilibrium valve to maintain a temperature at the indicating thermometer at 200° F.

When the condenser discharge water ceases to rise, start the pump. Repeat the process until an orifice plate is found that will give the minimum temperature of 194° F. plus. Seal the union through the bolts as provided.

Note: *If 200° F. cannot be obtained by adjusting the equilibrium valve, the orifice is too small. If the equilibrium valve adjustment permits a higher temperature than 200° F., the orifice is too large.*

Recorder-Controller (Initially and monthly): Reset the recorder-controller to the cut-in and cut-out temperature at 194° F. or higher against a known accurate indicating thermometer. Check the action of the recorder-controller by adjusting the equilibrium valve so that the temperature falls below 194° F. The pump must stop when 194° F. is reached. Seal the recorder-controller, and ecord your findings.

Check for the Controls That Require a Seal

The metering in-feed pump
The steam minimum pressure switch
The steam pipe union containing the orifice plate
The vacuum minimum pressure switch
The recorder-controller, which has been inspected and found free from any automatic cut-in device

Indicating Thermometer (Initially and every six months): Test the indicating thermometer against a known accurate thermometer at the pasteurization range of 194° F. Use a well-agitated water bath. Record the findings.

Miscellaneous Useful Data

● CERTAIN COMPARATIVE VALUES OF WATER, MILK, AND CREAM

Substance	Percent Butterfat	Percent Total Solids	Weight per Gallon
Water	-	-	8.34
Skim milk	0.20	8.20	8.64
Whole milk	3.00	11.40	8.59
Whole milk	4.00	12.30	8.61
Cream	20.00	27.13	8.43
Cream	40.00	45.35	8.28

WATER EQUIVALENTS:

1 cubic foot of water = 7.48 gals.

1 cubic foot of water = 62.4 lbs.

Head of water in feet x 0.433 = pounds pressure per square inch

Head of water in feet x 0.34 = pounds pressure per circular inch

Number of gallons of water contained in 1 foot of 1-inch pipe = 0.041 gallon.

● PREPARATION OF CHLORINE SOLUTIONS

To find the number of ounces of stock chlorine liquid or powder compound to make 100 gallons of a bactericidal solution, divide the strength of the solution desired by 0.781 times the percentage of available chlorine in the compound. This will give the number of ounces of compound to make up 100 gallons of bactericidal solution. For smaller amounts, divide 100 by the number of gallons of bactericidal solution being used.

Example:

It is desired to make 10 gallons bactericidal solution with 200 p.p.m. available chlorine.

$$\frac{200}{0.781 \times 21} = 12.1 \text{ oz.}$$

12.1 ÷ 10 = 1.2 oz of stock solution of 21 percent available chlorine

Where: 200 = strength of bactericidal solution desired in p.p.m. of available chlorine

21 = available chlorine in stock solution in percentage

0.781 = concentration of chlorine in p.p.m.

● PREPARATION OF CAUSTIC SOLUTIONS

Formula for computing the amount of caustic to add to a bottle-soaker tank to bring the solution to the desired percentage of free sodium hydroxide:

(a) $g \times 8.6 \frac{(x - n)}{100}$ = lbs. of caustic required to restore the remaining solution to the desired percentage

(b) $8.6 \times (G-g) \frac{x}{100}$ = lbs. of caustic to bring the water up to a desired percentage

G = capacity of tank in gallons

g = gallons remaining in tank after use

N = percent of caustic in remaining solution

x = percent of caustic desired in final solution

8.6 = weight in pounds per gallon of a 2-percent caustic solution

In restoring soaker solution, know:

1. Total capacity of tank
2. Volume remaining in tank
3. Strength of remaining solution
4. Desired solution strength

● MATHEMATICAL REMINDERS:

$\pi r^2 \times h$ = volume of cylinder in cu. ft.

π = 3.1416

r = radius of cylinder in feet

h = height of cylinder in feet

W x L x H = volume of rectangular or square-shaped tank in cu. ft.

W = width in feet

L = length in feet

H = height in feet

RELATION OF PRESSURE TO THE BOILING POINT OF WATER

Vacuum Gauge Reading Inches	Boiling Point Water Deg. F.	Pressure Pounds Per Sq. In.	Vacuum Gauge Reading Inches	Boiling Point Water Deg. F.	Pressure Pounds Per Sq. In.
0	212.0	14.696	22.5	149.2	3.396
1	210.2	14.206	23	147.2	3.396
2	208.6	13.716	23.5	143.4	3.156
3	207.0	13.226	24	140.4	2.906
4	204.8	12.736	24.5	136.9	2.666
5	203.0	12.236	25	133.2	2.416
6	201.0	11.746	25.5	129.2	2.176
7	198.9	11.256	26	124.7	1.926
8	196.7	10.766	26.5	119.7	1.676
9	194.5	10.276	27	114.1	1.436
10	192.2	9.786	27.5	107.6	1.186
11	189.7	9.296	28	99.9	0.946
12	187.2	8.806	28.2	96.1	0.846
13	184.6	8.316	28.4	92.1	0.746
14	181.8	7.816	28.6	87.8	0.646
15	178.9	7.326	28.8	82.6	0.556
16	175.8	6.836	29.0	76.5	0.456
17	172.6	6.346	29.1	73.2	0.406
18	169.0	5.856	29.2	69.3	0.356
19	165.2	5.366	29.3	64.9	0.306
20	161.2	4.876	29.4	59.9	0.256
20.5	159.1	4.626	29.5	54.1	0.206
21	156.7	4.386	29.6	46.9	0.156
21.5	154.4	4.136	29.7	37.0	0.106
22	151.9	3.886	29.74	32.0	0.086

Perfect vacuum = 29.921 inches of vacuum
= 14.696 lb.-per-sq.-inch reduction in pressure

To convert inches of vacuum to pounds pressure, use formula:

$$\text{Pounds per square inch} = \frac{14.696 \times (29.921 - \text{Inches vacuum})}{29.921}$$

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